

Department of the Interior
U.S. Geological Survey

USER GUIDE

LANDSAT LAND DATA OPERATIONAL PRODUCT EVALUATION (LDOPE) TOOLBELT

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Section 1 Introduction

Landsat satellite data have been produced, archived, and distributed by the U.S. Geological Survey (USGS) since 1972. Scientists and users rely on these data for historical study of land surface change, but shoulder the burden of post-production processing to create applications-ready data sets. In compliance with guidelines established through the Global Climate Observing System (GCOS), USGS has embarked on production of higher-level Landsat data products to support land surface change study.

The surface reflectance Climate Data Record (CDR), publicly available as a provisional product since 2012, is generated from specialized software called Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS). LEDAPS applies Moderate Resolution Imaging Spectroradiometer (MODIS) atmospheric correction routines to Level-1 Landsat Thematic Mapper (TM) or Enhanced Thematic Mapper Plus (ETM+) data. This production heritage gives Landsat surface reflectance some shared characteristics with MODIS, such as its Hierarchical Data Format for Earth Observing Systems (HDF-EOS) file structure and derived value specifications, which facilitate the use of MODIS tools to enhance the applicability of Landsat surface reflectance.

National Aeronautics and Space Administration (NASA) funded the MODIS Land Data Operational Product Evaluation (LDOPE) team to develop manipulation, visualization, and analysis tools for the MODIS user community. The resulting MODIS LDOPE Toolbox has been distributed without restriction since 2004 from the Land Processes Distributed Active Archive Center (LP DAAC). USGS has tested the functionality of the MODIS LDOPE Toolbox and found several tools to be relevant to Landsat surface reflectance products. The utility of some of them are described fully in a [USGS Techniques and Methods Report](#) (Jones, J., Starbuck, M., Jenkerson, C., 2013). A subset of the MODIS LDOPE Toolbox is packaged by the USGS as the Landsat LDOPE (L-LDOPE) Toolbelt.

The enclosed direction describing the functions delivered in the L-LDOPE Toolbelt is excerpted in whole or in part from the MODIS LDOPE Tools User's Manual, and adapted as needed to apply to Landsat surface reflectance products. All original code and documentation are used with permission from LDOPE and are available from LP DAAC at https://lpdaac.usgs.gov/tools/ldope_tools (last accessed December 12, 2012).

The L-LDOPE Toolbelt also includes a utility to support the extraction and interpretation of the bit-packed Quality Assurance (QA) layer in Landsat 8 Operational Land Imager (OLI) data files.

Section 2 **Use and Citation Information**

There are no restrictions on the use of the L-LDOPE Toolbelt, but please include the following citation in publication or presentation materials based on information derived from this software to credit the original development.

Roy, D.P., Borak, J.S., Devadiga, S., Wolfe, R.E., Zheng, M., Descloitres, J., 2002, The MODIS Land Product Quality Assessment Approach, Remote Sensing of Environment, v. 83, p. 62-76.

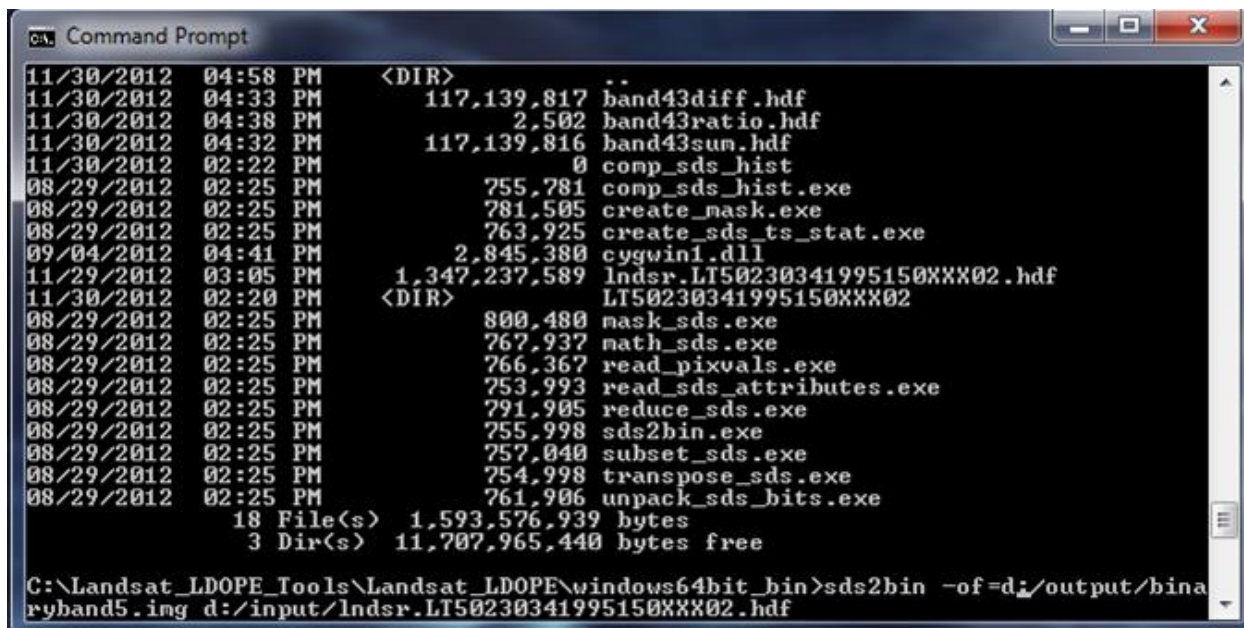
If possible, reprints or citations of papers or oral presentations based on information derived from this software are welcome at the User Services addresses included in this guide. Such cooperation will help USGS stay informed of how the software is being used.

Section 3 Download and Installation

The L-LDOPE Toolbelt is available at no cost from a USGS Web site, where a compressed file can be downloaded directly to a local drive. The software is delivered in a zip file that contains the executables compiled for Linux 32-Bit, Linux 64-Bit, Windows 32-Bit, and Windows 64-Bit systems, accompanied by the source code and a readme file. Installation steps are listed below.

1. Download “Landsat_LDOPE_Tools.zip” from http://landsat.usgs.gov/L-LDOPE_Toolbelt.php.
2. Unzip “Landsat_LDOPE_Tools.zip” to desired local directory, e.g. “C:\Landsat_LDOPE_Tools.”
3. Verify directory contents:
Landsat_LDOPE_Tools
 Landsat_LDOPE
 bin
 src
 linux32bit_bin
 linux64bit_bin
 windows32bit_bin
 windows64bit_bin
 Landsat_LDOPE_readme

Each command in the L-LDOPE Toolbelt can be run directly by typing the executable name and its parameters from the respective “bin” directory. The following snapshot shows command execution from a Windows Command Prompt display.



```
11/30/2012 04:58 PM <DIR>
11/30/2012 04:33 PM      117,139,817 band43diff.hdf
11/30/2012 04:38 PM          2,502 band43ratio.hdf
11/30/2012 04:32 PM      117,139,816 band43sum.hdf
11/30/2012 02:22 PM              0 comp_sds_hist
08/29/2012 02:25 PM       755,781 comp_sds_hist.exe
08/29/2012 02:25 PM       781,505 create_mask.exe
08/29/2012 02:25 PM       763,925 create_sds_ts_stat.exe
09/04/2012 04:41 PM       2,845,380 cygwin1.dll
11/29/2012 03:05 PM     1,347,237,589 lndsr.LT50230341995150XXX02.hdf
11/30/2012 02:20 PM <DIR>
08/29/2012 02:25 PM       800,480 mask_sds.exe
08/29/2012 02:25 PM       767,937 math_sds.exe
08/29/2012 02:25 PM       766,367 read_pixvals.exe
08/29/2012 02:25 PM       753,993 read_sds_attributes.exe
08/29/2012 02:25 PM       791,905 reduce_sds.exe
08/29/2012 02:25 PM       755,998 sds2bin.exe
08/29/2012 02:25 PM       757,040 subset_sds.exe
08/29/2012 02:25 PM       754,998 transpose_sds.exe
08/29/2012 02:25 PM       761,906 unpack_sds_bits.exe
18 File(s)  1,593,576,939 bytes
3 Dir(s)  11,707,965,440 bytes free

C:\Landsat_LDOPE_Tools\Landsat_LDOPE\windows64bit_bin>sds2bin -of=d:\output\binaryband5.img d:/input/lndsr.LT50230341995150XXX02.hdf
```

Section 4 **User Services**

The Landsat CDRs, Essential Climate Variables (ECV), and associated software tools and interfaces are supported by User Services staff at USGS Earth Resources Observation and Science Center (EROS). Any questions, comments, or problems are welcomed through the Landsat “Contact Us” on-line correspondence form. Please indicate “Surface Reflectance Data/LAI Request” as the topic of regard. Electronic mail can also be sent to the customer service address included below, with the same indication of topic.

USGS User Services

<http://landsat.usgs.gov/contactus.php>
custserv@usgs.gov

User support is available Monday through Friday from 8:00 a.m. – 4:00 p.m. Central Time. Inquiries received outside of these hours will be addressed during the next business day.

Section 5 Tool Overview

There are several components in the L-LDOPE Toolbelt that include functionality for computing histograms, creating masks, extracting statistics, reading metadata, reducing spatial resolution, band and spatial subsetting, and unpacking bit-packed values from the Landsat surface reflectance CDR. It also includes a tool that unpacks and extracts bits from the Landsat 8 OLI QA layer.

The tools are written in C and may be run at the command line or called from scripts and other packages. They are invoked using a UNIX-like command and argument syntax. All Landsat Surface Reflectance tools accept only HDF-EOS inputs, but write output files to conventional Hierarchical Data Format Version 4 (HDF4). The Landsat 8 OLI tool reads and writes only in Geographic Tagged Image File Format (GeoTIFF).

Table 1 L-LDOPE Toolbelt Function Summary

2D two dimensional, COTS commercial off the shelf software, HDF hierarchical data format, HDF-EOS HDF for Earth Observing Systems, SDS science data set

Tool	Description
comp_sds_hist	Print the histogram of SDS values (frequency and values), excluding no-data and missing values, of specified SDSs.
create_mask	Apply relational and logical operators to one or more SDS in one or more data products to create an output 2D HDF SDS that can be read by conventional COTS. For example, create a binary SDS that shows the pixel locations where only non-cloudy values over 5000 are present.
create_sds_ts_stat	Create a summary statistic HDF file containing one or more output 2D SDS that describe the mean, standard deviation, minimum, maximum, sum, and number of observations, computed on pixel-wise basis from a time series of input HDF-EOS files.
mask_sds	Mask one or more SDS of an input HDF-EOS file and output the SDS values at pixels where the mask criteria are met and output fill values elsewhere.
math_sds	Perform simple arithmetic on two input SDSs of the same or different input HDF-EOS files and output the results to a 2D SDS.
read_pixvals	Read input HDF-EOS file values at specified pixel locations.
read_sds_attributes	Print the attributes of one or more SDS of input HDF-EOS files.
reduce_sds	Generate reduced spatial resolution of an SDS in an input HDF-EOS file by sub-sampling or averaging. Handle the no-data and missing values. This may be used to reduce data volumes, and to quickly enable comparison with coarser resolution data products.
sds2bin	Convert an SDS of an input HDF-EOS file to a flat binary image format.
subset_sds	Create spatial subset SDS(s) from one or more SDS of an input HDF-EOS file.
transpose_sds	Transpose one or more SDS in an input HDF-EOS file by rotating the SDS 180 degree in clockwise direction. This tool was originally designed to enable qualitative comparison of files from opposite orbit paths.
unpack_oli_qa	For use only with Landsat 8 OLI QA files. This tool extracts either individual or combinations of QA bits and writes them to a GeoTIFF file in simple binary terms.

<i>*unpack_sds_bits</i>	<i>This tool decodes requested bit fields in bit-encoded SDSs and writes them to 2D HDF SDSs that can be read by conventional COTS.</i>
-------------------------	---

**NOTE: As of LEDAPS 1.0.0, quality assurance (QA) information is not bit-packed in a single science data set (SDS). Each QA condition has its own SDS and is expressed in simple “yes/no” terms (1 = yes, 0 = no). Using the “unpack_sds_bits” command is no longer necessary to extract QA, but remains part of the L-LDOPE Toolbelt.*

Section 6 **Tool Descriptions**

Each of the commands in the L-LDOPE Toolbelt is detailed in the sections below. Instruction or guidance is given in the context of name, synopsis, description, arguments, examples, and authors for each tool.

6.1 comp_sds_hist

NAME

comp_sds_hist – Print histogram of data values in one or more science data set (SDS) in an HDF-EOS data product.

SYNOPSIS

comp_sds_hist [-help] [filename]

comp_sds_hist [-sds=<SDS_name1>[,<SDS_name2>. . .]] [-layer]
[-range=<min,max>] filename

DESCRIPTION

Compute histogram of data values in one or more SDS(s). The histogram may be computed for a user specified range of SDS values. The output to stdout includes the SDS name, dimension size, fill value and a list of SDS values.

The tool command arguments can be specified in any order.

The histogram values are printed to screen only.

ARGUMENTS

- | | |
|------------------|---|
| -help | Display this help message. If the input filename is specified with this option, then the names of all the SDSs in the file are displayed. |
| -sds=<SDS_list> | List of SDSs to read. SDS names are separated by commas with no space. By default sds values are printed for all SDSs in the input file. |
| -layer | Compute histogram for every layer/slice separately for a multidimensional SDS. This option is not applicable to Landsat surface reflectance products. |
| -range=<min,max> | Histogram range (minimum and maximum values). Default is set to valid range of the SDS. Fill value is counted separately. If valid range attribute is not available the range of the SDS data type is |

used as the limit. The range value for various data type is shown below.

INT8: (-128, 127)

UINT8: (0, 255)

INT16: (-32768, 32767)

UINT16: (0, 65535)

INT32: (-2147483648, 2147483647)

UINT32: (0, 4294967295)

FLOAT32: UNDEFINED

For float data type the histogram is computed after converting the float values to their closest integer.

Filename Input filename(s).

EXAMPLES

```
C:\Landsat_LDOPE_Tools\Landsat_LDOPE\windows64bit_bin>comp_sds_hist  
-sds=band4 D:\LEDAPS1.1.0\LT50230341995150XXX02.hdf
```

```
C:\Landsat_LDOPE_Tools\Landsat_LDOPE\windows64bit_bin>comp_sds_hist  
-sds=band3,band2,band1 -range=0,10000  
D:\LEDAPS1.1.0\LT50230341995150XXX02.hdf
```

AUTHOR

Code: S. Devadiga and Yi Zhang

Documentation: S. Devadiga and D. Roy

Version 1.0, 04/05/2004

6.2 create_mask

NAME

create_mask - Create an output mask SDS containing two values: a user defined 'ON' value at pixels where the masking criteria are satisfied and an 'OFF' value elsewhere. The mask criteria are specified using relational and logical operators applied to the SDS of the same or different HDF-EOS data products.

SYNOPSIS

create_mask -help [filename]

create_mask -of=<output filename> -fill=<mask fill value>
-mask=<mask1>[,AND|OR,<mask2>][,...] [-on=<output ON value>]
[-off=<output OFF value>]
where maskn = <filename>,<SDSname>,<bit_numbers operator bit_values>

DESCRIPTION

Create an output masking SDS containing two values: a user defined 'ON' value at pixels where the masking criteria are satisfied and an 'OFF' value elsewhere.

The mask criteria are specified using relational and logical operators applied to the SDS of the same or different HDF-EOS data products. SDS(s) used to define the masking criteria must have the same or lower resolution as the input file SDS(s) to be masked.

The mask criteria are defined by a combination of one or more individual masks. Each mask is defined by testing SDS values against decimal values using a relational operator. Testing using a bit value is also supported, although it is not applicable to Landsat surface reflectance products. Different masks are combined using the logical "AND" or "OR" operators.

Masking criteria cannot be applied at pixels where one or more of the mask SDS(s) have fill values. A mask fill value will be output at these pixels. The mask fill value may be optionally specified or will be set to 255 by default.

The tool command arguments can be specified in any order.

The best results will be achieved when the input file resides in the same directory as the tool, e.g. windows64bit_bin.

ARGUMENTS

-help [filename]	Display this help message. If a filename is specified with this option, then the names of all the SDSs in the file are displayed.
-of=<filename>	Output filename.

-fill=<mask fill value> User specified mask fill value. The fill value is stored as the SDS attribute "Mask_FillValue" in the output file and is printed to stdout when the tool runs. If a mask fill value is not specified then an arbitrary value not equal to the input file SDS fill value and not equal to a valid input file SDS value is assigned.

-meta Copy metadata from the input file to the output file.

-mask=<mask1>[,AND|OR,<mask2>[,...]]

where mask_n=< filename>,<SDSname>,<bit_numbers operator bit_values>

Define a mask from one or more individual masks combined using the logical operators "AND" or "OR".

Each individual mask consists of:

-filename= HDF-EOS data product file

-SDSname= name of an SDS in the file

-bit_numbers= a list or range of SDS bits

-operator= relational operator (>, <, <=, >=, ==, !=)

-bit_values= bit values that are tested against

The bits in bit_numbers are specified by the lower bit followed by the higher bit and the bit_values are specified in the reverse order. For example, 0-2,4==0101 signifies bits 4,2,1,0==0101.

As Landsat surface reflectance products do not contain bit-encoded data, bit_numbers can be omitted. The bit_values will be parsed as a decimal value. This provides a convenient way to refer to a specific value, instead of a list of bits. For example, -mask=file,SDS,>=200 makes a mask where only the SDS values in the file greater than or equal to 200 are considered.

If several masks are combined together then '*' may be used in place of the filename and/or SDS name to specify the same filename and/or SDS name used in the previous mask. For example,

-mask=file1,SDS1,0-2,4==0101,AND,*,*,4-5==10

-on=<ON value> User defined output ON value.

-off=<OFF value> User defined output OFF value.

EXAMPLES

create_mask -of=D:\LEDAPS1.1.0\ndsrband1.greaterthan2000.hdf -on=1 -off=0
-mask="LT50230341995150XXX02.hdf,band1,>=2000"

create_mask -of=D:\LEDAPS1.1.0\ndsrallvisbands.greaterthan2000.hdf -on=1 -off=0

-mask="LT50230341995150XXX02.hdf,band1,>=2000,AND,
LT50230341995150XXX02.hdf,band2,>=2000,AND,
LT50230341995150XXX02.hdf,band3,>=2000"

AUTHOR

Code: S. Devadiga and Yi Zhang
Documentation: S. Devadiga and D. Roy
Version 1.0, 04/05/2004

6.3 create_sds_ts_stat

NAME

create_sds_ts_stat - Create a summary statistic HDF file containing one or more output 2D SDSs that describes the mean, standard deviation, minimum, maximum, sum, and number of observations, computed on pixel wise basis from a time series of input HDF-EOS data products.

SYNOPSIS

create_sds_ts_stat [-help] [filename]

create_sds_ts_stat -sds=<SDS_name,sds_minval,sds_maxval,f_nop_in,f_nop_out,dt>
-of=<filename> -param=[avg][,std][,min][,max][,npix][,sum] f1 [f2 .. . fn]

DESCRIPTION

Compute statistics of SDS values at each pixel from a set of input HDF-EOS data products. For example, the tool can be used to compute time series statistics of SDS values when the input files are a time series sequence of files for the same geographic area.

The output HDF file contains SDS of the following statistics: mean, standard deviation, minimum, maximum, number of pixels and sum of SDS values. By default all parameters are output.

The user can specify the range of the SDS values to be considered for computing statistics and a fill value to be excluded from consideration. Two or more SDSs are processed by repeating the option `-sds` with the SDS names. An input file is ignored if the user specified SDS is missing in that file.

ARGUMENTS

`-help` Display this help message. If the input filename is specified with this option, then the names of all the SDSs in the file are displayed.

`-sds=<SDS_name,sds_minval,sds_maxval,f_nop_in,f_nop_out,dt>`
Input SDS name, minimum and maximum of SDS values to be considered, no operation fill value in the input SDS, no operation fill value in the output SDS, output data type.

Input SDS pixel values equal to 'f_nop_in' are not considered. If no values are available for computing the statistics at a particular pixel then 'f_nop_out' is written to the pixel in the output SDS.

Each of the parameters except the SDS name can be replaced by * to assign default values defined as:

sds_min,sds_max: valid range of input SDS.

f_nop_in: input SDS fill value

f_nop_out: f_nop_in

dt: input SDS data type.

Valid values for output data type 'dt' are INT8, UINT8, INT16, UINT16, INT32, UINT32, FLOAT32

The output data type of SDS number of pixels is always INT16.

-param=avg,std,min,max,npix,sum

Output statistical parameters include average, standard deviation, minimum, maximum, number of pixels, and sum of SDS values at a pixel. One or more of these parameters may be specified in any order. If this argument is unspecified then all these parameters are output.

-of=<filename> Output filename

EXAMPLES

```
create_sds_ts_stat -sds="band4,* , * , * , *" -param=avg -of=
D:\LEDAPS1.1.0\Indsr.LT50230341995070AAA02.hdf
D:\LEDAPS1.1.0\Indsr.LT50230341995086XXX02.hdf
D:\LEDAPS1.1.0\Indsr.LT50230341995118AAA03.hdf
D:\LEDAPS1.1.0\Indsr.LT50230341995134XXX01.hdf
D:\LEDAPS1.1.0\Indsr.LT50230341995150XXX02.hdf
D:\LEDAPS1.1.0\Indsr.LT50230341995182XXX01.hdf
```

```
create_sds_ts_stat -sds="band1,* , * , * , *" -sds="band2,* , * , * , *" -sds="band3,* , * , * , *"
-param=npix,sum -of=D:\LEDAPS1.1.0\LT5023034_timeseriesstat_3band.hdf
D:\LEDAPS1.1.0\Indsr.LT50230341995070AAA02.hdf
D:\LEDAPS1.1.0\Indsr.LT50230341995086XXX02.hdf
D:\LEDAPS1.1.0\Indsr.LT50230341995118AAA03.hdf
D:\LEDAPS1.1.0\Indsr.LT50230341995134XXX01.hdf
D:\LEDAPS1.1.0\Indsr.LT50230341995150XXX02.hdf
D:\LEDAPS1.1.0\Indsr.LT50230341995182XXX01.hdf
```

AUTHOR

Code: S. Devadiga and Yi Zhang

Documentation: S. Devadiga and D. Roy

Version 1.0, 04/05/04

6.4 mask_sds

NAME

mask_sds – Mask one or more SDS(s) and output the SDS values at pixels where the mask criteria are met and output fill values elsewhere. The mask criteria are specified using relational and logical operators applied to the SDS of the same or different HDF-EOS data products.

SYNOPSIS

mask_sds -help [filename]

```
mask_sds -of=<output filename>  
        -sds=<SDSname1>[,<SDSname2>[,...]]>  
        [-fill=<mask fill value>]  
        -mask=<mask1>[,AND|OR,<mask2>[,...]] [-meta] filename  
        where maskn=< filename>,<SDSname>,<bit_numbers operator bit_values>
```

DESCRIPTION

Mask one of more SDS(s) and output the SDS values at pixels where the mask criteria are met and output mask fill values elsewhere.

The mask criteria are specified using relational and logical operators applied to the SDS of the same or different HDF-EOS data products. The SDS(s) used to define the masking criteria must have the same or lower spatial resolution as the input file SDS(s) to be masked.

The mask criteria are defined by a combination of one or more individual masks. Each mask is defined by testing SDS values against decimal values using a relational operator. Testing using a bit value is also supported, although it is not applicable to Landsat surface reflectance products. Different masks are combined using the logical “AND” or “OR” operators.

Pixel values that do not meet the masking criteria are assigned a mask fill value. The mask fill value may be optionally specified or will be set automatically. If the specified mask fill value is set equal to the input SDS fill value or to a valid input file SDS value then the tool will issue a warning message and request another mask fill value.

If pixels in the input file SDS(s) have fill values they cannot be masked. The input file SDS fill value will be output at these pixels.

If pixels in the SDS(s) used to define the masking criteria have fill values then the masking cannot be performed. The mask fill value will be output at these pixels.

The tool command arguments can be specified in any order.

The best results will be achieved when the input file resides in the same directory as the tool, e.g. windows64bit_bin.

ARGUMENTS

-help [filename] Display this help message. If the input filename is specified with this option, then the names of all the SDSs in the file are displayed.

-of=<filename> Output filename.

-sds=<SDS list> List of SDSs present in the input file to be masked and written to the output file. SDS names must be specified separated by commas with no space.

-fill=<mask fill value> User specified mask fill value. The fill value is stored as the SDS attribute "Mask_FillValue" in the output file and is printed to stdout when the tool runs. If a mask fill value is not specified then an arbitrary value not equal to the input file SDS fill value and not equal to a valid input file SDS value is assigned.

-meta Copy metadata from the input file to the output file.

-mask=<mask1>[,AND|OR,<mask2>[,...]] where
mask_n=<filename>,<SDSname>,<bit_numbers operator bit_values>
Define a mask from one or more individual masks combined using the logical operators "AND" or "OR".

Each individual mask consists of:

- filename= MODIS Land product file
- SDSname= name of an SDS in the file
- bit_numbers= a list or range of SDS bits
- operator= relational operator (>, <, <=, >=, ==, !=)
- bit_values= bit values that are tested against

The bits in bit_numbers are specified by the lower bit followed by the higher bit and the bit_values are specified in the reverse order. For example, 0-2,4==0101 signifies bits 4,2,1,0==0101.

As Landsat surface reflectance products do not contain bit-encoded data, bit_numbers can be omitted. The bit_values will be parsed as a decimal value. This provides a convenient way to refer to a specific value, instead of a list of bits. For example, -mask=file,SDS,>=200 makes a mask where only the SDS values in the file greater than or equal to 200 are considered.

If several masks are combined together then '*' may be used in place of the filename and/or SDS name to specify the same filename and/or SDS name used in the previous mask. For example, -mask=file1,SDS1,0-2,4==0101,AND,* ,*,4-5==10

filename Input filename

EXAMPLES

```
mask_sds -sds=cloud_QA  
-of=D:\LEDAPS1.1.0\cloud_with_band3_greaterthan2000.hdf  
-mask="Indsr.LT50230341995070AAA02.hdf,band3,>=2000"  
Indsr.LT50230341995070AAA02.hdf
```

AUTHOR

Code: S. Devadiga and Yi Zhang
Documentation: S. Devadiga and D. Roy
Version 1.0, 06/15/2003

6.5 math_sds

NAME

math_sds - Perform a simple arithmetic on two input SDSs of the same or different HDF-EOS data products.

SYNOPSIS

math_sds -help [filename]

math_sds -of=filename -math=<arithmetic expression>,dt,f_nop1,f_nop2,f_nop3,f_ovf
where arithmetic_expression = <SDS_name1,f1>,<op>,<SDS_name2,f2>

DESCRIPTION

Perform simple arithmetic on two input SDSs of the same or different HDF-EOS data products. Output is an HDF file containing the result of the pixel wise arithmetic operation.

The math option may be repeated with different arithmetic expressions to perform additional arithmetic on the same or different SDSs. Resulting SDSs of all arithmetic expressions are output to the same output HDF file.

If the input SDSs in an arithmetic expression are different resolutions, the resolution of one SDS must be an integral multiple of the other and the output SDS will be the higher of the two input resolutions.

The tool command arguments can be specified in any order.

ARGUMENTS

-help Display this help message. If the input filename is specified with this option, then the names of all the SDSs in the file are displayed.

-math=<arithmetic expression>,dt,f_nop1,f_nop2,f_nop3,f_ovf
The output data type 'dt' can be one of INT8, UINT8, INT16, UINT16, INT32, UINT32, or FLOAT32.

f_nop1 and f_nop2 are no operation fill values for the two input SDSs. The arithmetic operation is not performed at a pixel if the SDS value at the pixel in the input SDS1 is f_nop1 or SDS2 is f_nop2. If these arguments are unspecified then the input SDS fill values are used.

If the math operation cannot be performed at a pixel then the fill value f_nop3 is written to the output SDS pixel. If this argument is unspecified then the SDS 1 fill value is used.

The overflow fill value f_ovf is written to the pixel in the output SDS if the arithmetic operation at the pixel results in an overflow. If this argument is unspecified then the SDS1 fill value is used.

To set any fill values to default the * symbol may be specified in place of the actual value.

where arithmetic expression=<SDS_name1,f1>,<op>,<SDS_name2,f2>

The arithmetic expression contains two operands separated by an operator. Each operand contains an SDS and file containing the SDS separated by a comma. The mathematical operator can be one of (+, -, *, /). Expressions are evaluated from left to right.

-of=<filename> Output filename

EXAMPLES

```
math_sds -of=band43sum.hdf
-math=band4,Indsr.LT50230341995070AAA02.hdf,+,band3,
Indsr.LT50230341995070AAA02.hdf,*,*,*,*,*
```

```
math_sds -of=band43diff.hdf
-math=band4,Indsr.LT50230341995070AAA02.hdf,-,band3,
Indsr.LT50230341995070AAA02.hdf,*,*,*,*,*
```

AUTHOR

Code: S. Devadiga and Yi Zhang
Documentation: S. Devadiga and D. Roy
Version 1.0, 04/05/2004

6.6 read_pixvals

NAME

read_pixvals – Read HDF-EOS data product values at specified pixel locations.

SYNOPSIS

read_pixvals [-help] [filename]

read_pixvals -xy=col[.cs[.cs]],row[.rs[.rs]]<coordinates filename>
[-res=qkm|hkm|1km] filename(s)

DESCRIPTION

Read the pixel values at specified locations in one or more input HDF-EOS data products and output to stdout. The pixel values for each SDS in each file are output as separate lines.

The `-res` option in this tool is specific to MODIS Land HDF-EOS data products which may contain SDSs with different spatial dimensions corresponding to 250-meter (m), 500-m and 1-km pixel resolutions. For Landsat surface reflectance products, `-res` does not need to be specified. The `-xy` location will be assumed to reference the coarsest spatial resolution of the different SDSs.

Sub pixel locations may be output by specifying a sub pixel offset (0 or 1 in the x and/or y axes). If not specified a 0 pixel offset is assumed. See examples below.

The best results will be achieved when the input file resides in the same directory as the tool, e.g. windows64bit_bin.

ARGUMENTS

`-help [filename]` Display this help message. If the input filename is specified with this option, then the names of all the SDSs in the file are displayed.

`-res=qkm|hkm|1km` Reference SDS resolution (qkm=250m, hkm=500m, 1km=1000m) of the pixel location specified in the `-xy` argument. This variable should not be specified for Landsat surface reflectance products. The tool will use the coarsest resolution of all the SDSs in the input file list.

`-xy=col[.cs[.cs]],row[.rs[.rs]]<coordinates filename>`
Column and row pixel locations (0-based), or name of an ASCII coordinates file containing the column and row pixel locations. Multiple locations may be specified by repeating the `-xy` option or

by specifying the x and y coordinates on different lines in the ASCII coordinates file.

Sub pixel offsets for higher spatial resolution SDS may be specified as col.cs row.rs. This option is not necessarily applicable to Landsat surface reflectance products. The offsets refer to the top left corner pixel. For example:

-res=hkm -xy=100.0, 200.0
(read values at pixel 100,200 from the 500m SDS, and at pixel 200,400 from the 250m SDS)

-res=hkm -xy=100.1, 200.1
(read values at pixel 100,200 from the 500m SDS, and at pixel 201,401 from the 250m SDS)

-res=1km -xy=100.0.1,200.0.1
(read values at pixel 100,200 from the 1km SDS, at pixel 200,400 from the 500m SDS, and at pixel 401,801 from the 250m SDS)

filename(s) One or more input files separated by space.

EXAMPLES

read_pixvals -xy=6553,2551 Indsr.LT50230341995150XXX02.hdf

AUTHOR

Code: S. Devadiga and Yi Zhang
Documentation: S. Devadiga and D. Roy
Version 1.0, 06/15/2003

6.7 read_sds_attributes

NAME

read_sds_attributes - Read attributes of one or more SDS(s) in an input HDF-EOS data product.

SYNOPSIS

```
read_sds_attributes -help [filename]
```

```
read_sds_attributes [-sds=<SDS_name1>[,<SDS_name>. . ]] filename
```

DESCRIPTION

Read attributes of one or more SDSs of an input HDF-EOS data product and output the result to stdout. The SDS attributes include: fill values, units, scaling and offset values, SDS long name, etc.

ARGUMENTS

-help	Display this help message. If the input filename is specified with this option, then the names of all the SDSs in the file are displayed.
-sds=<SDS_list>	List of SDS to process. SDS names are separated by commas with no space. By default attributes for all SDSs in the input file are output.
filename	Input filename.

EXAMPLE

```
read_sds_attributes D:\LEDAPS1.1.0\Indsr.LT50230341995070AAA02.hdf
```

```
read_sds_attributes -sds=fill_QA D:\LEDAPS1.1.0\Indsr.LT50230341995070AAA02.hdf
```

AUTHOR

Code: S. Devadiga and Yi Zhang
Documentation: S. Devadiga and D. Roy
Version 1.0, 04/05/2004

6.8 reduce_sds

NAME

reduce_sds - Reduce the spatial dimensions of one or more SDS(s) in an input HDF-EOS data product.

SYNOPSIS

reduce_sds -help [filename]

reduce_sds -of=<output_filename> -rf=<reduction factor> -sub|avg|cnt|cl
[-sds=<SDSname1>[<,SDSname2>...]]
[-bit=[<bit range>]<opr><value>[,<bit range>]<opr><value>]...]
[-min] [-max] [-std] [-num] [-meta] [-float] filename

DESCRIPTION

The spatial dimensions of input SDS(s) may be reduced using one of four different methods. The reduction factor (rf) must be a non-zero positive integer. The output SDS x dimension will be $((x \text{ div } rf) + (x \text{ mod } rf))$ and similarly the y dimension will be $((y \text{ div } rf) + (y \text{ mod } rf))$. If the input SDS list contains SDSs with different spatial dimensions the reduction factor will be applied to the SDS with the smallest spatial dimension and the other SDS(s) will be reduced to have the same output dimension.

All SDS fill values are ignored.

This tool may be used to reduce data volumes, and to enable quick comparison with other coarser spatial resolution data sets.

The tool command arguments can be specified in any order.

ARGUMENTS

- | | |
|------------------------|--|
| -help [filename] | Display this help message. If the input filename is specified with this option, then the names of all the SDSs in the file are displayed. |
| -of=<filename> | Output filename |
| -rf=<reduction factor> | Reduction factor (a non-zero positive integer) |
| -sub | Reduce by sub-sampling. Pixel value at (i, j) in the output SDS is copied from the pixel at $(rf*i + rf/2, rf*j + rf/2)$ in the input SDS. |
| -avg | Reduce by averaging. Pixel value at (i, j) in the output SDS is the average of pixel values in a sub window defined from $(rf*i, rf*j)$ to |

$(rf*i + rf - 1, rf*j + rf - 1)$ in the input SDS. Optional minimum, maximum, standard deviation, and number of averaged pixels may be output as separate SDS.

-cnt Reduce by pixel counting. Pixel value at (i, j) in the output SDS is the number of pixels in a sub window defined from $(rf*i, rf*j)$ to $(rf*i + rf - 1, rf*j + rf - 1)$ in the input SDS with bit value equal to the user specified value. Relational operators may be used. The output SDS value is in the range $\{0 : rf \times rf\}$.

-cl Reduce by majority class value. Pixel value at (i, j) in the output SDS is set to the majority value of the pixels in a sub window defined from $(rf*i, rf*j)$ to $(rf*i + rf - 1, rf*j + rf - 1)$. This option is best used for data with a small number of nominal pixel values.

-sds=<SDS list> List of SDSs to reduce. SDS names are separated by commas with no space. By default all SDSs are processed maintaining the input SDS interleaving.

-bit=[<bit range>]<operator><value>,[<bit range>]<operator><value>, . . .

This option is applicable only with the **-cnt** option. The SDS bit range and corresponding value are specified in decimal separated by a relational operator. If the bit range is not specified the tool considers all the bits in the SDS. Multiple range, operator and value combinations separated by commas will result in separate output SDS for each of such combination. Valid relational operators are: ==, <, >, <=, >=, !=

-std Compute the standard deviation in each sub window (for -avg option only).

-min Compute the minimum value in each sub window (for -avg option only).

-max Compute the maximum value in each sub window (for -avg option only).

-num Compute the number of averaged pixels in each sub window (for -avg option only).

-meta Copy metadata from input file to output file.

-float Output average value SDS in float data type, default is the input data type (for -avg option only).

Filename Input filename.

EXAMPLES

```
reduce_sds -sds=band1 -sub -rf=2 -of=reduceby2_for_band1_at_60m.hdf  
D:\LEDAPS1.1.0\Indsr.LT50230341995150XXX02.hdf
```

```
reduce_sds -sds=band2 -avg -num -rf=4 -of=reduceby4_for_band2_at_120m.hdf  
D:\LEDAPS1.1.0\Indsr.LT50230341995150XXX02.hdf
```

AUTHOR

Code: S. Devadiga and Yi Zhang
Documentation: S. Devadiga and D. Roy
Version 1.0, 08/08/2002

6.9 sds2bin

NAME

sds2bin - Convert an SDS in an HDF-EOS data product to binary format.

SYNOPSIS

sds2bin -help [filename]

sds2bin -of=<output filename> -sds=<SDSname> filename

DESCRIPTION

Convert a user specified SDS from an HDF-EOS data product to an output binary format file.

The tool command arguments can be specified in any order.

ARGUMENTS

-help [filename] Display this help message. If the input filename is specified with this option, then the names of all the SDSs in the file are displayed.

-of=<filename> Output filename.

-sds=<SDS name> SDS to be converted

Filename Input filename.

EXAMPLES

```
sds2bin -sds=band5 -of=binaryband5.img  
D:\LEDAPS1.1.0\Indsr.LT50230341995150XXX02.hdf
```

AUTHOR

Code: S. Devadiga and Yi Zhang
Documentation: S. Devadiga and D. Roy
Version 1.0, 08/08/2002

6.10 subset_sds

NAME

subset_sds - Create spatial subset SDS(s) of one or more SDS(s) in an input HDF-EOS data product.

SYNOPSIS

subset_sds -help [filename]

subset_sds -of=<output filename> -row=<start,end> -col=<start,end>
[-sds=<SDS_name1>[,<SDS_name2>,. . .]] filename

DESCRIPTION

Create spatial subset SDS(s) of one or more SDS(s) of an input HDF-EOS data product. The spatial subset is specified by the pixel row-column range in the input product.

The tool command arguments can be specified in any order.

ARGUMENTS

- | | |
|--------------------|---|
| -help | Display this help message. If the input filename is specified with this option, then the names of all the SDSs in the file are displayed. |
| -sds=<SDS_list> | List of SDS to subset. SDS names are separated by commas with no space. By default all SDSs are subsetted maintaining the input SDS interleaving. |
| -row=<start,end> | Subset row range (start and end are inclusive) |
| -col=<start,end> | Subset column range (start and end are inclusive) |
| -of=<out filename> | Output filename |
| Filename | Input filename |

EXAMPLES

```
subset_sds -sds=band1,band2,band3 -row=4025,6154 -col=2759,6488  
D:\LEDAPS1.1.0\lndsr.LT50230341995150XXX02.hdf -of=D:\LEDAPS1.1.0\shorty.hdf
```

AUTHOR

Code: S. Devadiga and Yi Zhang

Documentation: S. Devadiga and D. Roy
Version 1.0, 04/05/2004

6.11 transpose_sds

NAME

transpose_sds - Transpose one or more SDS(s) by rotating the SDS 180 degrees in a clockwise direction.

SYNOPSIS

transpose_sds help [filename]

transpose [-sds=<SDS_name>1[,<SDS_name2>. .]] -of=<output_file>
[-meta] filename

DESCRIPTION

Transpose one or more SDS(s) by rotating the SDS 180 degrees in a clockwise direction. This tool enables qualitative comparison of data from satellites in opposite orbits.

The tool command arguments can be specified in any order.

ARGUMENTS

- | | |
|-----------------|---|
| -help | Display this help message. If the input filename is specified with this option, then the names of all the SDSs in the file are displayed. |
| -sds=<SDS_list> | List of SDSs to transpose. SDS names are separated by commas with no space. By default all SDSs are processed maintaining the input SDS interleaving. |
| -of=filename | Output filename. |
| -meta | Copy metadata from the input file to the output. |
| filename | Input filename. |

EXAMPLES

```
transpose_sds -sds=band1,band2,band3 -of=D:\LEDAPS1.1.0\transposed.hdf  
D:\LEDAPS1.1.0\Indsr.LT50230341995150XXX02.hdf -meta
```

AUTHOR

Code: S. Devadiga and Yi Zhang
Documentation: S. Devadiga and D. Roy
Version 1.0, 04/05/2004

6.12 unpack_oli_qa

NAME

unpack_oli_qa – Extract specified bits from the Landsat 8 OLI QA band and writes them to individual GeoTIFFs, or combines them into a single GeoTIFF.

SYNOPSIS

unpack_oli_qa -help [filename]

unpack_oli_qa --ifile=input_QA_filename --ofile=output_unpacked_QA_filename [--all=conf_level] [--fill=conf_level] [--drop_frame=conf_level] [--terrain_occl=conf_level] [--water=conf_level] [--cloud_shadow=conf_level] [--veg=conf_level] [--snow_ice=conf_level] [--cirrus=conf_level] [--cloud=conf_level] [--combine]

DESCRIPTION

Landsat 8 OLI QA bits can be extracted into individual QA bands output to multiple files, or as combinations of bits output to a single file. The output bands will refer to the QA bits (from right to left), representing the QA information which is stored in the QA band.

In some cases a single bit is used to represent quality data in the OLI QA band and in other cases two bits are used to describe conditions that may affect pixel quality.

For quality data represented by a single bit, the output values are as follows:

0 = No, this condition does not exist
1 = Yes, this condition exists

For quality data represented by two bits, the user has the option to specify the confidence levels included in the mask. The current confidence levels in the OLI QA band are as follows:

00 = Algorithm did not determine the status of this condition
01 = Algorithm has low confidence that this condition exists (0-33 % confidence)
10 = Algorithm has medium confidence that this condition exists (34-66 % confidence)
11 = Algorithm has high confidence that this condition exists (67-100 % confidence)

If the user specifies a confidence level of 'low' for a confidence field, then the output mask will be flagged as "1" (yes) if the 2-bit confidence value is low, medium, or high. If the user specifies a confidence level of 'med' for the confidence field, then the output mask will be flagged as "1" (yes) if the confidence value is medium or high. And, if the user specifies a confidence level of 'high', then the output mask will be flagged as "1" (yes) if the confidence value is high.

The following table identifies the output quality band and how it correlates to the bits in the individual QA bands, when not using combine bits. The user may select to combine

the specified QA bits into one single output file. In that case, if any of the specified QA bits meet the specified confidence level, then the output mask for that pixel will be flagged as “1” (yes).

Tool Output	QA Bit(s)	Description
_fill.tif	0	Fill
_dropped_frame.tif	1	Dropped Frame
_terrain_occl.tif	2	Terrain Occlusion
N/A	3	Reserved
_water.tif	4-5	Water Confidence
_cloud_shadow.tif	6-7	Cloud Shadow Confidence
_vegetation.tif	8-9	Vegetation Confidence
_snow_ice.tif	10-11	Snow/Ice Confidence
_cirrus.tif	12-13	Cirrus Confidence
_cloud.tif	14-15	Cloud Confidence

The tool command arguments can be specified in any order.

ARGUMENTS

- help Display this help message. If the input filename is specified with this option, then the names of all the SDSs in the file are displayed.
- ifile Name of the input QA file (unsigned 16-bit integer GeoTIFF).
- ofile Basename of the output file if bit combination is not used, otherwise the full name of the output file (unsigned 8-bit integer GeoTIFF to match the user-specified quality bits).
- combine Indicates the specified QA bits will be combined into one single output band, e.g., create an output file with all pixels that are either cloudy or water flagged “1” (yes). Default is false.
- all Output all the quality bits (0-15) using the specified confidence level for 2-bit QA fields. Default is true.
- fill Output the fill bit (0).
- drop_frame Output the dropped frame bit (1).
- terrain_occl Output the terrain occlusion bit (2).
- water Output the water bits (4, 5) using the specified confidence level ('low', 'med', or 'high'). Default is 'med.'

-cloud_shadow	Output the cloud shadow bits (6, 7) using the specified confidence level ('low', 'med', or 'high'). Default is 'med.'
-veg	Output the vegetation bits (8, 9) using the specified confidence level ('low', 'med', or 'high'). Default is 'med.'
-snow_ice	Output the snow/ice bits (10, 11) using the specified confidence level ('low', 'med', or 'high'). Default is 'med.'
-cirrus	Output the cirrus bits (12, 13) using the specified confidence level ('low', 'med', or 'high'). Default is 'med.'
-cloud	Output the cloud bits (4, 5) using the specified confidence level ('low', 'med', or 'high'). Default is 'med.'

EXAMPLES

Unpack all the QA bits into their own single-band GeoTIFF files. Use the default of medium confidence (and above) for the 2-bit quality fields. The command is typed entirely on one line.

```
unpack_oli_qa --ifile=LC80340322013132LGN01_BQA.tif --
ofile=LC80340322013132LGN01 --all
```

Unpack the fill, water, vegetation, snow/ice, and cloud quality fields each into their own GeoTIFF file. The fill field (single-bit) does not require a confidence level. Water pixels will be masked if their confidence level is high. Vegetation pixels will be masked if their confidence level is low, medium, or high. Snow/ice pixels will be masked if their confidence is medium or high (the default). Cloud pixels will also be masked if their confidence level is medium or high. The command is typed entirely on one line.

```
unpack_oli_qa --ifile=LC80340322013132LGN01_BQA.tif --
ofile=LC80340322013132LGN01 --fill --water=high --veg=low --snow_ice --cloud=med
```

Unpack the fill, cloud, and cirrus quality fields each into one combined file. The fill field (single bit) does not require a confidence level. Cloud pixels will be masked if their confidence level is high. Cirrus pixels will be masked if their confidence level is low, medium, or high. The command is typed entirely on one line.

```
unpack_oli_qa --ifile=LC80340322013132LGN01_BQA.tif --
ofile=LC80340322013132LGN01_mask.tif --fill --cloud=high --cirrus=low --combine
```

AUTHOR

Code: G. Schmidt
Documentation: G. Schmidt
Version 1.0, 07/08/2013

6.13 unpack_sds_bits

NAME

unpack_sds_bits – Extract specified bits from one or more bit-encoded SDS(s) in an input HDF-EOS data product.

SYNOPSIS

unpack_sds_bits -help [filename]

unpack_sds_bits -of=<output filename> [-sds=<SDSname1>[<,SDSname2>...]
-bit=<Bitnumbers> -meta filename

DESCRIPTION

This tool is no longer needed for extraction of quality assurance (QA) information from Landsat surface reflectance products, but is retained in the L-LDOPE Toolbelt nonetheless. Please refer to the [MODIS LDOPE Toolbox User Manual](#) for further information.

Appendix A Acronyms

Acronym	Description
2D	Two Dimensional
CDR	Climate Data Record
COTS	Commercial Off The Shelf
DAAC	Distributed Active Archive Center
DOI	Department of the Interior
ECV	Essential Climate Variable
EOS	Earth Observing System
EROS	Earth Resources Observation and Science
ETM+	Enhanced Thematic Mapper Plus
GCOS	Global Climate Observing System
GeoTIFF	Geographic Tagged Image File Format
HDF	Hierarchical Data Format
LDOPE	Land Data Operational Product Evaluation
LEDAPS	Landsat Ecosystem Disturbance Adaptive Processing System
L-LDOPE	Landsat-LDOPE
LP	Land Processes
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
OLI	Operational Land Imager
QA	Quality Assurance
SDS	Science Data Set
TM	Thematic Mapper
USGS	U.S. Geological Survey